

# NATIONAL BUREAU OF STANDARDS REPORT

8343

Development, Testing, and Evaluation of Visual Landing Aids  
Consolidated Progress Report for the Period January 1 to March 31, 1964

By  
Photometry and Colorimetry Section  
Metrology Division



U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

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\* NBS Group, Joint Institute for Laboratory Astrophysics at the University of Colorado.

\*\* Located at Boulder, Colorado.

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## NBS PROJECT

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## NBS REPORT

8343

April 1964

Development, Testing, and Evaluation of  
Visual Landing Aids

Consolidated Progress Report  
to  
Ship Aeronautics Division  
and  
Meteorological Management Division  
Bureau of Naval Weapons  
Department of the Navy  
  
and to  
Federal Aviation Agency  
Washington, D. C.

For the Period  
January 1 to March 31, 1964

By  
Photometry and Colorimetry Section  
Metrology Division

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U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS



Development, Testing, and Evaluation of Visual Landing Aids  
January 1 to March 31, 1964

I. REPORTS ISSUED

<u>Report No.</u>	<u>Title</u>
8167	Photometric Characteristics of a Lens Cell of the Fresnel-Lens Optical Landing System
8169 and 8169 Supp.	An Investigation of Beam-Spreading Techniques for Semi-flush-Prismatic Type Airport-Marker Lights
8188	Methods of Modifying the Transmissometer System to Permit Its Use During Periods of Very Low Runway Visual Range
8303	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period October 1 to December 31, 1963
21P-59/62 Supp.	Luminous Output Measurements and Life Tests of Six Developmental 6000-Hour Lamps for Use in a 300-mm Code, or Hazard, Beacon
21P-67/63 Supp. (Letter Report)	Tests of Top Plates for Inset Light Manufactured by Structural Electric Products Corporation
21P-102/63	Luminous Output and Intensity Distribution Measurements of Seven Developmental 6000-Hour Lamps with C-5 Filaments, For Use in a 300-mm Code, or Hazard, Beacon
21P-103/63	Photometric Tests of a Type B-3 Semiflush-Mount Omnidirectional Airport-Marker Light Manufactured by Multi Electric Mfg. Inc.
21P-106/63	Effective Intensity Measurements of a Condenser-Discharge Light Manufactured by Electronic Lights, Inc.
21P-111/63	Effective Intensity Measurements of a Condenser-Discharge Light Manufactured by Don Hoskins, Inc.
21P-11/64	Photometric Tests of Two Type 20A/PAR56 Approach-Light Lamps Manufactured by Sylvania Electric Products Inc.
21P-16/64	Design and Construction of Feasibility Models of a Portable Spot-Pad Light for Helicopters



Report No. (cont.)Title (cont.)

21P-19/64	Photometric Tests of Two Deck Guide Lights for Aircraft Carriers, Manufactured by L.C. Doane Co.
Letter Report	Preproduction Models of Two Deck Lights Manufactured by Sylvania Electric Products, Inc.
Memorandum Report	Investigation of the Effect of Line Voltage on the Sensitivity of the Transmissometer Receiver

## II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter. The slant visibility meter test records for the 1962 fog season were reviewed to determine the thickness of the base layer during fog conditions. Records for about 60 hours were available for visibilities of one-half mile or less with the recorder driving at fast speed. Each scan was evaluated for the height of the top of the base layer and also for the maximum height below which the fog could be considered as a single layer, referred to here as the basic layer. This basic layer may consist of only a single base layer or it may be several layers that are so similar the difference between the recorded values of response and the computed values, based on a single layer in which the attenuation varies linearly with height, is not more than twenty percent. These heights were grouped within intervals of 50 feet from 0 to over 400 feet. The height of the top of the base layer exceeded 50 feet for more than 95 percent of the time and exceeded 100 feet for 75 percent of the time during the recorded scans. The height of the top of the basic layer was nearly 150 feet for 95 percent of the time and exceeded 350 feet for 75 percent of the time. The percentage of time the top of the base and of the basic layer exceeded the indicated height for each 50-foot interval is shown in table 1.

Table 1

Height of top of layer $\longrightarrow$ (feet)	0	50	100	150	200	250	300	350	400
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Values given below are the percent of scans with the height of the top of the layer exceeding indicated height (from total of 1200 scans).

Base Layer	100	97	87	69	56	47	40	37	31
Basic Layer	100	100	98	93	89	84	81	77	72





The FAA meteorological observations for the period November 1962 to October 1963 were analyzed to determine the frequency of occurrence and the number of hours of low-visibility and low-ceiling conditions at Arcata Airport. These data indicate a close correlation between low-visibility and low-ceiling conditions and indicate that the airport is closed more by low visibility than it is by low ceiling.

Shipboard Visibility Meter. Further tests have been made in an attempt to improve the signal-to-noise ratio during good visibility daylight conditions. The output of the flashlamp was doubled by increasing the size of the capacitors from forty to eighty  $\mu$ fd and the background illumination was decreased by adding baffles in the photomultiplier receiving tube.

Several methods of gating the signal pulse have been tested in an effort to separate the signal pulse from the background noise. A photodiode placed in the beam of the flashlamp was tried and discarded because the voltage pulse generated by it was of a greater magnitude than the signal pulse. Mechanical gates are not practical because of the short time duration required if the gate is to be of value.

Measurements made of the output of the instrument in both very good visibility ( $>10$  miles) and low visibility ( $1/4$  mile) showed that if the voltage applied to the photomultiplier is not reduced as the visibility decreases, the output signal strength when the visibility is  $1/4$  mile would be about 1000 times the output signal strength in clear weather. This range in signal strength is too large to be handled readily. Therefore preliminary designs have been made of circuitry which will adjust the voltage applied to the photomultiplier to maintain a constant output signal. The visibility would then be proportional to the logarithm of this voltage.

A conference has been held with personnel of the National Bureau of Standards Electronic Instrumentation Section in preparation for building a unit designed for shipboard testing and evaluation.

#### Transmissometer.

Transmissometer Modifications to Adapt the Instrument for Use in Very Dense Fogs.— The analysis of methods of modifying the transmissometer has been completed and released as NBS Report 8188. The analysis indicates that shortening the baseline is the preferred modification when the minimum RVR required is 800 feet or lower. Compensation for the reduction in length of baseline can be made by the use of two short-baseline transmissometers in an essentially end-to-end position.



Effect of Line Voltage on the Sensitivity of the Transmissometer Receiver.— Recently transmissometer receivers have been found to change sensitivity as the line voltage changed. The cause of the sensitivity change was traced to oscillations in the discharge through the trigger tube. Only the trigger tubes manufactured in recent years showed this effect. The addition of a damping resistor in the plate circuit of this tube eliminated the sensitivity change. The study has been reported in a Memorandum Report.

Airborne Turbidity Meters. Two airborne-type turbidity meters manufactured by Cook Electric Company have been received from the Bureau of Naval Weapons for examination with a view toward increasing the sensitivity. Three anticollision-light switches of the same general design were obtained from within the National Bureau of Standards. Preliminary examination revealed that none of the instruments was operating properly and that no two had the same symptoms of failure. Therefore, before the study is continued all instruments are being reworked to remove and replace defective components and to put them into their original operating condition.

Study of Systematic Variations of Fog. During this quarter the tabulation of the transmittance comparison data for the period of November and December 1963 was completed. The data were tabulated for periods when the transmittance was below 0.70. However, the data start before the low transmittance period and stop after that period; thus almost all ranges of transmittance are represented.

Each data set consists of the readings of the transmissometers T-S, T-F, and T-H taken at five-minute intervals. The arrangement of the transmissometers is shown in figure 1. The readings were corrected for background and 100-percent setting. Ratios of the readings were then computed.

The ratios, classified by intervals of transmittance ranges, are shown in table 2.



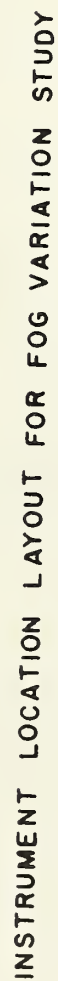
Table 2

Transmittance Ratios of 8 Fogs (Nov. - Dec. 1963)

Transmittance- Range Intervals (from measure- ment by T-H)	<u>Number of Comparisons</u>			<u>Average Ratios of Transmittance Measurements</u>		
	T-H and T-S	T-F and T-S	T-H and T-F	$\frac{T-H}{T-S}$	$\frac{T-F}{T-S}$	$\frac{T-H}{T-F}$
0.000-0.099	101	105	101	0.667	1.099	0.657
0.100-0.199	21	21	21	0.631	1.084	0.622
0.200-0.299	13	13	13	0.772	0.966	0.828
0.300-0.399	18	18	18	0.986	0.962	1.036
0.400-0.499	11	11	11	0.939	0.913	1.010
0.500-0.599	25	25	25	0.976	0.955	1.063
0.600-0.799	99	100	99	1.015	0.975	1.047
0.800-1.00	<u>120</u>	<u>118</u>	<u>115</u>	1.029	0.974	1.071
Totals	408	411	403			

The transmissometers T-S, T-F, and T-H all have 500-foot baselines and are arranged as shown in figure 1. T-S and T-F were roughly end-to-end and the line of sight of T-H passed near the common ends of T-S and T-F. The point where T-H crossed T-S and T-F was near the section of the projector beam of the slant visibility meter viewed by the receiver when the beam is horizontal.





### Figure 1





### III. AIRFIELD LIGHTING AND MARKING

Stub Approach Beacon. A continuously-variable autotransformer was installed for use in adjusting the intensity of the lights for night-time. No pilot comments from approaches at night have been obtained since this transformer was installed. Pilot comments from approaches in daytime indicate that the 500-watt, type 20A/PAR56Q/1 lamps operated at 100 percent intensity are very satisfactory. In the arrangement using five lamps, symmetrically arranged, and rotated at 12 revolutions per minute (60 flashes per minute) these lamps proved more effective than the type 20A/PAR56Q/3 lamps because of their wider horizontal beam spread. After some pilot comments from nighttime approaches at different intensity settings are recorded, this investigation will be complete.

Navy Taxiway Lighting Standard. The draft of this Standard has been revised into final form.

Top Plate for Inset Lights. A top plate for a Structural Electric Products inset light made of passivated, fully hardened type 410 stainless steel was subjected to salt spray tests. There was some evidence of rust (staining). A letter report supplementary to NBS Test Report 21P-67/63, describing the tests, has been released.

Semiflush-Mount Omnidirectional Airport-Marker Light. Test Report 21P-103/63 was issued giving results of tests of a stray-light shield for use in a type B-3 semiflush-mount omnidirectional airport-marker light. The shield is effective in preventing stray white light from being emitted when a blue filter is used in the unit.

700-Watt, C-7a, 6000-Hour Lamps for Code Beacons. Test Report 21P-59/62 Supplementary was issued giving the results of life tests of six 700-watt, 6000-hour code beacon lamps with C-7a filaments. The 64% (4200 hours) efficacy maintenance at 70% of life was low compared to the 86% specification requirements for 500/IF (1000-hour life) lamps and to the 90% specification requirements for 200-watt, 2500-hour lamps.

700-Watt, C-5, 6000-Hour Lamps for Code Beacons. Life tests of four 700-watt, 6000-hour code beacon lamps (with C-5 filaments) are continuing. One lamp burned out after 3000 hours of burning time. Luminous output maintenance will be determined after 4200 hours (70% of rated life). NBS Test Report 21P-102/63 was issued giving the results of initial luminous output and intensity distribution measurements. The intensity distribution measurements were made of the output of one section of a 300-mm beacon using two of the lamps in turn. These lamps provided a peak intensity 30% greater than that provided by a 500-watt lamp. The vertical beam spread at 50% of peak intensity is 23% greater.



Type 20A/PAR56 Approach-Light Lamp. Photometric tests were made of two 300-watt, 20-ampere sealed-reflector lamps with "approach-light" covers, type 20A/PAR56. The lamps met the requirements of FAA Drawing C-5407-1 with respect to the 16,000-isocandela pattern and beam placement. The vertical intensity distribution curve through  $0.0^\circ$  horizontal showed cyclic changes in intensity at angles greater than  $\pm 10^\circ$  vertical with the intensity varying from about 400 to 2000 candelas. Although this light variation is not noticeable when the lights are viewed from the approach glide slope, it creates a problem for maintenance personnel who make checks from the ground to determine if a lamp is properly aimed or if the intensity is becoming too low. NBS Report 21P-11/64 has been issued.

Condenser-Discharge Approach Light. Effective-intensity distribution measurements of a condenser-discharge light (type P/N 85-003-1) manufactured by Don Hoskins, Inc. show a peak effective intensity of about 6 kilocandelas. The light, intended for use in small-airfield approach light systems, operates at 120 v.a.c. input at 60 flashes per minute with a power consumption of about 90 watts. Flashing is accomplished by interrupting the input voltage. Tests indicated that if the input voltage were not interrupted, the voltage applied to the charging capacitor would exceed the rated voltage of the capacitor. NBS Report 21P-111/63 has been issued.

Helicopter Identification Light. Effective intensity distribution measurements of an experimental condenser-discharge light (type EL-ASN-500M) manufactured by Electronic Lights, Inc. show a peak effective intensity of about 5 kilocandelas. The light, intended for use as a helicopter identification light, operates at 208 v.a.c. input at 90 flashes per minute at a power consumption of about 416 watts. The glass lens cracked during the early part of the test, but not in an area that would affect the photometric results. NBS Report 21P-106/63 has been issued.

Test Method for Semiflush Lights. Further work was done on the problem of developing test methods for semiflush lights which use PAR-type lamps. A test jig that partially collimated the light from a quartzline lamp worked satisfactorily in determining the elevation of the beam.

Beam Spreading Techniques for Semiflush-Prismatic Type Airport-Marker Lights. NBS Reports 8169 and 8169 Supplementary were issued giving the results of tests of the feasibility of incorporating a cylindrical plano-convex lens into the optical system of B- and BB-type semiflush-prismatic type airport-marker lights. With the type BB light, the vertical beam spread was increased from  $4.6^\circ$  to  $16.2^\circ$  (using a 500-watt lamp) without lowering the peak intensity; with the type B light, the vertical beam spread was increased from about  $8^\circ$  to values ranging from  $10^\circ$  to  $19^\circ$ , depending on the position of the lens. The peak intensities were, however, lower with the type B unit when the lens was in place. The work did not determine optimum lens placement or focal length, but was done only to evaluate the basic principle.



Lighting for SATS Airfields. Two SATS series-series, 20/6.6-ampere, 200-watt transformers were tested to determine their operating characteristics when each of two 90-volt, 100T10/2P lamps manufactured by General Electric Company was the load. For the tests these transformers were connected to 6.6-ampere runway-light circuits and to a 20-ampere approach-light circuit'. The tests were conducted when these circuits were operated with all of their lamps burning and with open secondaries for part of the isolating transformers. Tests were made for both conditions and all five steps of brightness transformers. The lamps were connected to the 6.6-ampere winding of the SATS transformer. Tests were made using a 4-kw, 6.6-ampere regulator at Washington, the 15-kw, 6.6-ampere type NC3 runway-lighting constant-current regulator at Arcata, and a Hevi Duty Electric Co. 40-kw, 20-ampere, type CCRA approach-light regulator at Arcata. . When a 6.6-ampere regulator was used, a 6.6/20-ampere isolating transformer was connected between the runway-lighting circuit and the SATS transformer for correct current matching. In addition, tests were made with the 90-volt 100T10/2P lamps connected as the load for standard 6.6/6.6-ampere, 200-watt transformers in the runway-lighting circuit. The 90-volt lamp appears to be satisfactory for use with 6.6-ampere, 200-watt transformers where a saturated type of operation is desired. The results will be reported in detail soon.

Of special interest during the tests of the SATS transformers was a loud vibration noise emitted from each SATS transformer when it was operated with a 90-volt lamp as load or with an open secondary winding. These transformers were not noisy with a regular 200-watt, 6.6-ampere lamp connected to them. The noise level and tonal quality changed when stress was placed on the transformer cases with the hands, indicating poor potting or loose laminations.

Effective Intensity of PAR-Type Lamps Used in Rotating Beacons. Additional work is being performed, including the investigation of type 399PAR, 300PAR/NSP, and 6.6A/PAR56/2 lamps.

Effective Intensity of Flashing PAR399 Lamps. A report on the study of the intensity-time curves of the flashing PAR399 lamp is being prepared.

Field Tests of Cable-Test-Detecting Set AN/TSM-11. The draft of the report on the field testing of the Cable-Test-Detecting Set AN/TSM-11 has been revised to include the findings of the recent tests on the semi-flush light circuit of Runway 13-31 at the Arcata Airport. The results of tests conducted on the Runway 13-31 lights, as stated in the previous quarter, are substantially the same as those reported for the tests made of the light circuit on Runway 01-19. For soil with low conductivity, it is difficult to locate cable faults accurately, except direct grounds.





Studies of Cable Deterioration. A meeting was held with Defense Department and FAA personnel to discuss modification of Specification MIL-C-4921, Cable, Power, Electrical, Airport Lighting, to require greater resistance to micro-organism (fungus) attack of the cable. Mr. N. E. Alexander, Fort Detrick, Maryland, agreed to inspect samples sent to him to determine if micro-organisms are the offending agents. NBS personnel tried to generate some interest in the testing of newly developed elastomers for resistance to micro-organism attack.

#### IV. SEADROME LIGHTING

FMF6 Seadrome Light. Drawings of the redesigned FMF6 seadrome light were received from NAEL(SI) for review. The design of the light is based on the photoelectric control - static inverter unit designed and tested at the National Bureau of Standards. (See NBS Reports 5889, 5891, 6225, and 7040.) The drawings were reviewed in detail and returned with comments.





## V. CARRIER LANDING AIDS

Photometry of the Fresnel-Lens Optical Landing System. NBS Report 8167 was issued giving the results of an investigation into the photometry of a diverging lens system such as the one used in the Fresnel-Lens Optical Landing System. The report shows that (1) the photometric computations based on the inverse square law must include a correction based on the apparent distance of the virtual image from the lens and (2) there are no "hot spots" on the face of the lenses that would show up as ghosts to a pilot not on the glide slope.

Two Deck Guide Lights for Aircraft Carriers. Photometric measurements were made of two deck guide lights for aircraft carriers manufactured by the L. C. Doane Company. Some difficulty was encountered with the first unit received in that the lamp holder did not make contact with the lamp and that the lens was not properly installed. A redesigned unit was submitted with an improved lamp holder, but the lens was inverted, as was that of the first unit. Peak intensities between 700 and 800 candelas were obtained with the lamps and lenses properly positioned. With four possible positions for the lens and the lamp, it was suggested that some method be used to insure proper assembly and maintenance procedures.

NBS Test Report 21P-19/64 has been issued.

Experimental Deck Guide Light. A Letter Report of tests on two experimental deck guide lights manufactured by Sylvania Electric Products, Inc. has been issued, stating that the fiber optic in each light unit failed during operation. A second set of parts for the lights has been received. Again, two 100-watt and two 160-watt lamps were included. One of the new fiber optic assemblies was similar to the earlier ones tested at NBS. The second was new, containing fibers of much larger diameter in the same optic area as before. Tests have indicated that this second set of lamps is faulty. Another set is to be forwarded by the manufacturer.

Portable Spot-Pad Light for Helicopters. NBS Report 21P-16/64 was issued. It describes the design and construction of the portable spot-pad lights intended for use on carrier decks to mark landing spots for helicopters. After suitability tests of the seven lights constructed were made, an eighth light was constructed for use as a model during the preparation of a specification. It has been delivered to the Naval Air Engineering Laboratory (Ship Installations).

LPH Angle-of-Approach Light. The LPH angle-of-approach light has been completed for installation and evaluation aboard ship. A description of the light is given in NBS Report 8303.



## VI. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Specifications. The following specifications were reviewed and comments forwarded.

MIL-D-4806A	Distribution Box, Runway Lighting, 5000 Volt, 20 Ampere, Type MA-1
MIL-L-7835B (Weps)	Light, Marker, Seadrome Runway, Battery-Static Inverter Power, Fluorescent, and referenced Drawings (See Seadrome Lighting)
MIL-P-8944	Panel, Airport Lighting Control, General Requirements for
MIL-R-8945	Relay Assembly, Pilot, Enclosed, Airport Lighting, General Specification for, associated MS Drawings, and preceding Specifications.
MIL-L-26202	Light, Marker, Airport, Semiflush, General Specification for, and associated MS Drawings.
MIL-T-27535	Transformer, Power, Isolation; Series Circuit, Airport Lighting, General Specification for, and associated MS Drawings.

NAEL-MISC-08309, Naval Air Station Survey of Visual Landing Aids Systems and Component Parts was also reviewed.

Several meetings of Defense Department and of Federal Aviation Agency Ad Hoc groups reviewing specifications have been attended and suggestions for modifications based on work performed at the National Bureau of Standards were presented.

Miscellaneous Consultive Services. Technical assistance has been given to personnel of the Federal Aviation Agency in the interpretation of the results, reported by a contractor, of field studies of the lighting and marking of TV towers; to Weather Bureau personnel on problems related to automatic intensity control of visual aids, and to several industrial organizations on problems related to the transmittance of infrared energy through fog, to fog dispersal, and to the design of visual glide slope indicators.

Theory of the Photometry of Projection Apparatus. The first draft of a report "Review of the Elementary Theory of the Photometry of Projection Apparatus" has been completed. The principles developed in this report have been applied to the interpretation of the measurements made of the output of a cell of the Fresnel Lens Optical Landing System. The results of this application were reported in NBS Report 8167.



Preparation of Lamp Lists. Two meetings were held, one with Navy personnel and one with members of the Large Lamp Subcommittee of the Illuminating Engineering Society. The main topic of discussion was a review of airport and airway lamps for listing in the forthcoming Lighting Handbook, 4th Edition.

## VII. MISCELLANEOUS

Remoting Flight Service Station. The Federal Aviation Agency has announced that the Flight Service Station at Arcata will be remoted in the next 12 to 24 months. This change is being opposed by many local organizations and individuals. If this facility is remoted, our operations will be affected in some respects. We will lose our convenient access to weather forecasts and local observations. Other arrangements for notification outside of regular working hours of the existence of conditions suitable for testing will be required. Means of contacting pilots for comments while they are in the air will be lost. Our ability to work on and near the runways and taxiways will be affected by difficulties in obtaining permission and clearance to get into these areas and by the increased hazard from operation of aircraft whose positions and intentions are unknown to the remote facility. These features affect the convenience of our operations, but should not seriously hamper our ability to continue operation at this site.

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